CARDIOVASCULAR MEDICINE

"Diastolic heart failure" or heart failure caused by subtle left ventricular systolic dysfunction?

M C Petrie, L Caruana, C Berry, J J V McMurray

Heart 2002;**87**:29–31

See end of article for authors' affiliations

Correspondence to: Professor J J V McMurray, Wolfson Building, University of Glasgow, Glasgow G12 8QQ, UK; j.mcmurray@bio.gla.ac.uk

Accepted 28 June 2001

Objectives: To determine whether patients with suspected heart failure but preserved systolic function, as determined by conventional echocardiographic measures (often said to have "diastolic heart failure), might have subtle left ventricular systolic dysfunction detectable by a new measure of left ventricular systolic function—left ventricular systolic atrioventricular plane displacement.
Design: Observational study.
Setting: Direct access echocardiography.
Patients: 147 patients with suspected heart failure referred by general practitioners.
Measurements: Echocardiographic assessment of conventional measures of left ventricular systolic function (fractional shortening, ejection fraction (by Simpson's biplane method) and "eyeball" assessment) and measurement of left ventricular systolic atrioventricular plane displacement.
Results: Between 21% and 33% of patients with "normal" left ventricular systolic function by conventional methods were found to have abnormal left ventricular systolic atrioventricular plane displacement.
Conclusions: Approximately one quarter of patients with suspected heart failure but preserved systolic function by conventional methods have abnormal atrioventricular plane displacement. These patients with suspected heart failure but preserved systolic function by conventional echocardiographic measures may have heart failure caused by subtle systolic dysfunction rather than isolated "diastolic heart failure".

Patients with the signs and symptoms of heart failure but apparently normal left ventricular systolic function (and no other obvious cause of heart failure) present a puzzle. Accumulating reports suggest that up to one third, or even one half, of all patients with a clinical diagnosis of heart failure are of this type.[1–5] Recent studies suggest that these patients have a prognosis that is nearly as bad as that for patients with heart failure and reduced left ventricular systolic function.[6 7] Despite this, we do not really understand what is wrong with patients who seem to have heart failure and apparently preserved systolic function. Perhaps more important, we do not know how to treat them.

Though it has become popular to describe these patients as having "diastolic heart failure" caused by "diastolic dysfunction", it is also possible that unrecognised, subtle left ventricular systolic function may be present. Diastolic dysfunction is usually assumed because some measure of left ventricular systolic function is found to be within a normal range. Typically, this is left ventricular ejection fraction, left ventricular fractional shortening, or, more commonly, an "eyeball" assessment. Recently, what is thought to be a better measurement of predominantly systolic function has been described. Left ventricular systolic atrioventricular (AV) plane displacement, principally a measure of left ventricular systolic function, may be more sensitive than conventional indices.[8–15] This technique measures longitudinal rather than circumferential shortening of the left ventricle.

METHODS

Patients

The cohort of patients studied was that referred by general practitioners to a direct access echocardiography service at the department of cardiology at the Western Infirmary, Glasgow. The indication for referral for all patients was suspected heart failure. The focus of this analysis was patients with preserved left ventricular systolic function (defined by conventional methods as described below). Patients with significant valve disease or atrial fibrillation were not studied further.

Transthoracic echocardiography

All examinations were performed by a single operator (LC) on an Acuson 128XP10c (Acuson Corporation; Mountain View, California, USA). With the patient resting in the left lateral decubitus position M mode, two dimensional, and Doppler ultrasound examinations were carried out.

Conventional measurements of left ventricular systolic function

Left ventricular systolic function was quantified using M mode fractional shortening (< 25% was considered impaired) and ejection fraction was measured using Simpson's biplane method, as described previously.[16] Qualitative "eyeball" assessment of the two dimensional images (categorising all as impaired or preserved) was also carried out.[16–18]

Measurement of systolic AV plane displacement

Systolic AV plane displacement was measured according to the methods of Willenheimer and colleagues.[14] Briefly, this index was evaluated using two dimensionally guided M mode echocardiography in the two and four chamber views. The regional displacement (in millimetres) was the distance covered by the AV plane between the position most remote from the apex (corresponding to the onset of contraction) and the position closest to the apex (corresponding to the end of contraction, including any postejection shortening)—that is, the full extent of the displacement. This was measured in the septal, lateral, posterior, and anterior regions and was calculated from an average of four measurements. The mean of the systolic AV plane displacement in the four regions was then calculated.

Table 1 Patient characteristics and medication

	All (n=131)	AVPD ⩾10 (n=76)	AVPD <10 (n=40)
Patient characteristics			
Age (years)	72 (11)	70 (11)	73 (10)
Male sex (n, %)	46 (35)	27 (36)	15 (38)
Systolic BP (mm Hg)	149 (23)	152 (21)	145 (23)
Diastolic BP (mm Hg)	84 (11)	83 (11)	82 (10)
Heart rate (beats/min)	76 (18)	73 (18)	78 (19)
Fractional shortening (%)	28 (8)	30 (7)	24 (9)
Ejection fraction (M mode) (%)	52 (13)	56 (11)	48 (14)
Ejection fraction (Simpson's biplane) (%)	42 (11)	48 (10)	34 (9)
Hypertension (n,%)	55 (42)	38 (50)	13 (32)
Myocardial infarction (n,%)	14 (11)	5 (7)	6 (15)
Coronary artery bypass grafting (n,%)	9 (7)	5 (7)	3 (7)
Pulmonary disease (n,%)	29 (22)	16 (21)	9 (22)
Medication			
Diuretics (n,%)	90 (69)	48 (63)	32 (80)
β Blockers (n,%)	21 (16)	10 (13)	8 (20)
Nitrates (n,%)	29 (22)	15 (20)	11 (28)
Calcium channel blockers (n,%)	22 (17)	16 (21)	4 (10)
ACE inhibitors (n,%)	17 (13)	4 (5)	11 (28)
Aspirin (n,%)	36 (27)	20 (26)	11 (28)
Inhaled β_2 agonists (n,%)	25 (19)	10 (13)	10 (25)
Inhaled corticosteroids (n,%)	11 (8)	5 (7)	4 (10)
Oral hypoglycaemic agents (n,%)	6 (5)	4 (5)	2 (5)
Lipid lowering drugs (n,%)	4 (3)	3 (4)	1 (3)
Non steroidal anti-inflammatory drugs (n,%)	11 (8)	7 (9)	2 (5)
Digoxin (n,%)	9 (7)	1 (1)	7 (18)

Data are mean (SD) unless otherwise indicated. ACE, angiotensin converting enzyme; AVPD, atrioventricular plane displacement; BP, blood pressure

RESULTS

Patients

One hundred and forty seven patients with suspected heart failure were referred. Ten patients had atrial fibrillation alone, two patients had valve disease alone, and four patients had both atrial fibrillation and valve disease. The remaining 131 patients with suspected heart failure in the absence of valve disease or atrial fibrillation were the focus of the study. Table 1 summarises characteristics of these patients. In keeping with epidemiological studies, the patients were elderly and frequently women.

Prevalence of abnormalities of systolic AV plane displacement in patients with preserved left ventricular systolic function

Between 21% and 33% of patients with "normal" left ventricular systolic function as determined by conventional methods (fractional shortening, ejection fraction (by Simpson's biplane method), qualitative "eyeball" assessment) were found to have abnormal systolic AV plane displacement (table 2).

Measurement of fractional shortening, ejection fraction by Simpson's biplane method, and systolic AV plane displacement was not possible in 49 (37%), 36 (27%), and 15 (11%) patients, respectively. An "eyeball" assessment was possible in each case.

DISCUSSION

The principal finding of this study is that a substantial proportion of patients with suspected heart failure and apparently preserved systolic function, as assessed by conventional measures, may have an unrecognised reduction in left ventricular contractility. Depending on which measure of systolic function and what "upper limit of normal" is considered, between 21–33% of the cohort studied were found to have abnormally low systolic AV plane displacement. This finding raises the possibility that many patients thought to have "diastolic dysfunction" may, in fact, have systolic dysfunction undetected by the measurements usually made when patients with suspected heart failure undergo echocardiographic assessment. Before accepting this point of view, one must ask what exactly does systolic AV plane displacement measure and why should this index identify abnormalities apparently missed by conventional indices such as fractional shortening and left ventricular ejection fraction?

Systolic AV plane displacement is quite different from left ventricular ejection fraction and other conventional measurements of left ventricular systolic function. Whereas the latter

Table 2 Systolic atrioventricular plane displacement (AVPD) in patients with preserved LV systolic function

	Preserved fractional shortening		Preserved LV ejection fraction by Simpson's biplane method		Preserved LV systolic function by "eyeball" assessment (109/131)
Systolic AVPD (mm)	⩾25% (55/82)	⩾30% (34/82)	⩾ 35% (68/95)	⩾ 40% (57/95)	
⩾10 (n,%)	38 (70)	25 (74)	44 (65)	40 (70)	74 (68)
8.2–9.9 (n,%)	13 (24)	9 (26)	20 (29)	16 (28)	25 (19)
6.4–8.1 (n,%)	3 (5)	0 (0)	3 (4)	0 (0)	3 (2)
<6.4 (n,%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Not measurable	1 (2)	0 (0)	1 (1)	1 (2)	7 (6)

Total number of patients referred with suspected heart failure was 147. Two had valve disease alone, 10 had atrial fibrillation alone, and four had valve disease and atrial fibrillation. The total number of patients studied was 131. Forty nine had no measureable fractional shortening (therefore, n = 82 for fractional shortening (82 + 49 = 131)). Thirty six had no ejection fraction measureable by Simpson's biplane method (therefore n = 95 for ejection fraction by Simpson's biplane method (95 + 36 = 131)). Fifteen had no measureable AVPD. LV, left ventricular.

assess mainly contraction of circumferentially orientated fibres, systolic AV plane displacement is related more to contraction of longitudinal fibres.[8–15] Systolic AV plane displacement assesses global left ventricular function as it is measured in four separate regions of the left ventricle (septal, lateral, posterior, and anterior) and, consequently, describes total shortening along the left ventricular long axis.[8–15] Though different from ejection fraction, AV plane displacement does correlate with the former measure.[14] More important, reduced systolic AV plane displacement is a powerful predictor of poor prognosis.[14 19] Indeed, it is worth noting that patients with an AV plane displacement of < 10 mm (that is, below our upper limit of normal) have a 25% mortality rate at one year. This may be one explanation for the hitherto surprising observation that patients with heart failure and a normal left ventricular ejection fraction, around 25% of whom we would suggest have reduced systolic AV plane displacement, have a poor outcome.[6] This is often not much better than that of patients with a depressed ejection fraction. The high mortality in this group of patients may also reflect the likely alternative diagnoses found in patients with suspected heart failure but preserved left ventricular systolic function.[16]. Patients with obesity, chronic obstructive pulmonary disease, and myocardial ischaemia all have well recognised increased mortality.

Systolic AV plane displacement may have one other important advantage over conventional measures of systolic function. We were able to measure it in 89% of our population in contrast to fractional shortening, which could be measured in only 63% of patients, and ejection fraction (Simpson's biplane method), measurable in 73%.

One limitation of our analysis and interpretation is that AV plane displacement may also give some measure of diastolic function as well as systolic function. However, the correlation between AV plane displacement and reliable indices of left ventricular systolic function is very strong (r values > 0.8).[9 10] That between AV plane displacement and indices of diastolic dysfunction is much weaker.[20 21] It is also difficult to know how to interpret correlations with indices that are themselves thought to be of uncertain value—for example, E:A ratio.

Our findings add further to the emerging debate about what has been called "diastolic heart failure". Many suspected of having this syndrome have alternative explanations for their symptoms (such as chronic lung disease, myocardial ischaemia, obesity) and may not have heart failure at all.[16] Even among those who do, there is difficulty in deciding whether "diastolic dysfunction" is present because there are few agreed upon non-invasive indices and those that have been suggested show very poor concordance (resulting in vastly differing prevalences of "diastolic dysfunction").[22] For this reason the term "heart failure with normal (or preserved) systolic function" has become more popular and patients described in this way are now being recruited into two large placebo controlled outcome trials, one with an angiotensin converting enzyme inhibitor and the other with an angiotensin receptor blocker.[23 24] Our findings, however, suggest that even these terms may be imprecise. It may be more accurate to describe such patients as those with the syndrome of heart failure and a normal ejection fraction, or whatever conventional index is used. It may also be time to start using AV plane displacement, a very readily obtainable and reproducible measurement.

Authors' affiliations
M C Petrie, L Caruana, C Berry, Department of Cardiology, Western Infirmary of Glasgow, Glasgow, UK
J J V McMurray, Department of Medicine and Therapeutics, Western Infirmary of Glasgow

REFERENCES

1 **Bonow RO**, Udelson JE. Left ventricular diastolic dysfunction as a cause of congestive heart failure: mechanisms and management. *Ann Intern Med* 1992;**117**:502–10.
2 **Litwin SE**, Grossman W. Diastolic dysfunction as a cause of heart failure. *J Am Coll Cardiol* 1993;**22**:A49-55.
3 **Brutsaert DL**, Sys SU, Gillebert TC. Diastolic failure: pathophysiology and therapeutic implications. J Am Coll Cardiol 1993;**22**:318–25.
4 **Lenihan DJ**, Gerson MC, Hoit BD, *et al*. Mechanisms, diagnosis, and treatment of diastolic heart failure. Am Heart J 1995;**130**:153–66.
5 **Mandinov L**, Eberli FR, Seiler C, *et al*. Diastolic heart failure. *Cardiovasc Res* 2000;**45**:813–25.
6 **Senni M**, Tribouilloy CM, Rodeheffer RJ, *et al*. Congestive heart failure in the community: a study of all incident cases in Olmsted County, Minnesota, in 1991. *Circulation* 1998;**98**:2282–9.
7 **Vasan RS**, Benjamin EJ, Levy D. Prevalence, clinical features and prognosis of diastolic heart failure: an epidemiologic perspective. *J Am Coll Cardiol* 1995;**26**:1565–74.
8 **Hoglund C**, Alam M, Thorstrand C. Effects of acute myocardial infarction on the displacement of the atrioventricular plane: an echocardiographic study. *J Intern Med* 1989;**226**:251–6.
9 **Alam M**, Hoglund C, Thorstrand C, *et al*. Atrioventricular plane displacement in severe congestive heart failure following dilated cardiomyopathy or myocardial infarction. *J Intern Med* 1990;**228**:569–75.
10 **Alam M**. The atrioventricular plane displacement as a means of evaluating left ventricular systolic function in acute myocardial infarction. *Clin Cardiol* 1991;**14**:588–94.
11 **Alam M**, Rosenhamer G. Atrioventricular plane displacement and left ventricular function. *J Am Soc Echocardiogr* 1992;**5**:427–33.
12 **Alam M**, Hoglund C, Thorstrand C, *et al*. Haemodynamic significance of the atrioventricular plane displacement in patients with coronary artery disease. *Eur Heart J* 1992;**13**:194–200.
13 **Alam M**, Hoglund C. Serial echocardiographic studies following thrombolytic treatment in myocardial infarction with special reference to the atrioventricular valve plane displacement. *Clin Cardiol* 1992;**15**:30–6.
14 **Willenheimer R**, Cline C, Erhardt L, *et al*. Left ventricular atrioventricular plane displacement: an echocardiographic technique for rapid assessment of prognosis in heart failure. *Heart* 1997;**78**:230–6.
15 **Willenheimer R**. Assessment of left ventricular dysfunction and remodelling by determination of atrioventricular plane displacement and simplified echocardiography. *Scand Cardiovasc J Suppl* 1998;**48**:1–31.
16 **Caruana L**, Petrie MC, Davie AP, *et al*. Do patients with suspected heart failure but preserved left ventricular systolic function suffer from diastolic heart failure or from misdiagnosis? *BMJ* 2000;**321**:215–8.
17 **Willenheimer R**, Erhardt L, Dahlof B. Simplified echocardiography: an accurate and inexpensive method for the assessment of left ventricular hypertrophy. *Eur Heart J* 1999;**20**:1437–8.
18 **Willenheimer RB**, Israelsson BA, Cline CM, *et al*. Simplified echocardiography in the diagnosis of heart failure. *Scand Cardiovasc J* 1997;**31**:9–16.
19 **Willenheimer RB**, Erhardt LR, Cline CM, *et al*. Prognostic significance of changes in left ventricular systolic function in elderly patients with congestive heart failure. *Coron Artery Dis* 1997;**8**:711–7.
20 **Willenheimer R**, Israelsson B, Cline C, *et al*. Left atrioventricular plane displacement is related to both systolic and diastolic left ventricular performance in patients with chronic heart failure. *Eur Heart J* 1999;**20**:612–8.
21 **Rydberg E**, Willenheimer R, Brand B, *et al*. Left ventricular diastolic filling is related to the atrioventricular plane displacement in patients with coronary artery disease. *Scand Cardiovasc J* 2001;**35**:30–4.
22 **Caruana L**, Davie AP, Petrie M, *et al*. Diagnosing heart failure. *Eur Heart J* 1999;**20**:393.
23 **Cleland JG**, Tendera M, Adamus J, *et al* for the PEP investigators. Perindopril for elderly people with chronic heart failure: the PEP-CHF study. *Eur J Heart Fail* 1999;**1**:211–7.
24 **Swedberg K**, Pfeffer M, Granger C, *et al*. Candesartan in heart failure: assessment of reduction in mortality and morbidity (CHARM): rationale and design. *J Card Fail* 1999;**5**:276–82.